EXHAUST EMISSIONS FROM ALTERNATIVE FUEL VEHICLES

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In an ongoing effort to support the U.S. Department of Energy's Alternative Fuels Utilization Program, Southwest Research Institute (SwRI) has conducted three independent studies for the National Renewable Energy Laboratory (NREL) to show the emissions benefits of alternative fuel vehicle technology.

In the first study, jointly funded by NREL, ARCO, and SwRI, a TLEV-certified light-duty vehicle was modified to operate on butane, butane blends, and propane. Regulated exhaust emissions, speciated hydrocarbon emissions, ozone-forming potentials, and specific reactivity factors were determined for a vehicle operating on 11 test fuels including California Phase 2 gasoline, industry average gasoline, 100% propane, 100% n-butane, 90% n-butane/10% isobutane, 90% n-butane/10% mixed butenes, 60% n-butane/40% isobutane, 80% n-butane/20% propane, 90% n-butane/10% n-pentane, and 50% n-butane/50% propane. Utilizing the Federal Test Procedure (FTP), a total of 18 exhaust emissions tests were conducted. At the mileage tested, the vehicle met ULEV standards while operating on all of the alternative fuels except a 100% n-butane fuel and a 90% n-butane/10% pentane fuel blend. The best emissions results were achieved with the vehicle operating on 100% propane, followed by a 50% n-butane/50% propane blend.

The second study evaluated the effectiveness of NREL's variable-conductance-insulation (VCI) catalytic converter in reducing cold-start exhaust emissions after extended soak periods. Regulated exhaust emissions and estimated NMOG emissions from a TLEV-certified vehicle operating on E85 (85% denatured ethanol/15% gasoline) and equipped with the VCI catalyst were determined utilizing the FTP. Five different combinations of vehicle preconditioning and soak period sequences were evaluated. Following extended vehicle preconditioning and a 24-hour soak period, the VCI catalyst reduced hydrocarbon (HC) and carbon monoxide (CO) emissions by over 90% and oxides of nitrogen (NO_x) emissions by 75% compared to the stock catalytic converter. After a standard vehicle preconditioning cycle and a 36-hour soak with the VCI system, HC, CO, and NO_x exhaust emissions were reduced 30%, 20%, and 55%, respectively, compared to baseline levels. As expected, most of the emission reductions were achieved in the first few minutes of the cold-start phase of the FTP.

In the third study, small-diameter particulate matter was characterized from a flexible-fueled light-duty vehicle operating on Federal Reformulated Gasoline (RFG), M85 (85% methanol/15% gasoline), E85 (85% denatured ethanol/15% gasoline), liquefied petroleum gas (LPG) meeting HD-5 specifications, and compressed natural gas (CNG). The vehicle was operated fuel-rich to simulate an engine failure mode for the increased production of particulate matter. Particulate emissions were characterized by total mass and particle size. A total of 10 exhaust emission evaluations were performed using the FTP. Total particulate mass did not exceed the 1996 light-duty vehicle particulate emission standard for any of the fuels, even while operating at rich fuel/air equivalence ratios. The trend for total particulate mass emissions during rich operation was LPG < CNG < E85 < M85 < RFG. Particulate emissions during rich operation on LPG and CNG were similar to those observed for the vehicle while running at stoichiometry on gasoline.

The overall project is being extended to investigate the impact of winter temperatures and stoichiometric vehicle operation on particulate formation. Exhaust particulate will be characterized for total mass, size distribution, unburned oil contribution, polynuclear aromatic hydrocarbons, elemental content, and trace organic constituents. In addition, close-coupled light-off catalyst technology will be developed and evaluated for use on ethanol-fueled vehicles.